Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

Circular No. 704

Issued August 1944 • Washington, D. C.

Slightly revised March 1947

UNITED STATES DEPARTMENT OF AGRICULTURE

Sampling and Measuring Methods for Determining Fineness and Uniformity in Wool

By Elroy M. Pohle, *associate animal fiber technologist*, L. N. Hazel, *assistant animal husbandman*, and H. R. Keller, *assistant animal husbandman, Bureau of Animal Industry, Agricultural Research Administration, United States Department of Agriculture* [1]

CONTENTS

	Page
Introduction	1
Experimental material	2
Results and discussion	7
Sampling methods	7
Methods of measuring mean diameter	11
Results and discussion—Continued	
Methods of estimating uniformity of fineness	13
Summary	14
Literature cited	15

INTRODUCTION

In the large-scale breeding operations carried on by the United States Department of Agriculture at the Western Sheep Breeding Laboratory, Dubois, Idaho, for the improvement of sheep produced under range conditions, average fineness and uniformity of the fleece from each prospective breeding animal must be known. Consequently, the authors have had occasion to compare different methods of sampling individual fleeces and various ways of measuring their fineness and uniformity in achieving a practical degree of accuracy with a minimum amount of labor.

A technique for measuring the diameter of fibers by cross sectioning small samples and photographing the enlarged image has been developed by Hardy (*6*).[2] For widespread application this basic technique needs to be modified for two reasons: (1) Individual fleeces and lots of wool are not uniform in diameter; (2) the measuring of individual fibers in large numbers requires considerable time and calculation. Malan and coworkers (*10*) have outlined the difficulties concerned with the first problem. Other investigations by Wilson (*15*), Burns (*4*), Bailey (*2*), Ensminger (*5*), and Pohle and Schott (*12*) have shown that there is a gradient in fineness from the front to the rear of a fleece. Pohle and Schott (*12*) have found that sheep are not ranked in the

[1] Observational and experimental data by Elroy M. Pohle and H. R. Keller; statistical analysis by L. N. Hazel. The work was done at the Western Sheep Breeding Laboratory, Dubois, Idaho, under authority of the Bankhead-Jones Act.

[2] Italic numbers in parentheses refer to Literature Cited, p. 15.

same order for fineness by samples taken from different body regions or from different levels along the fiber.

In connection with the second problem, Hardy and Wolf (*7*) developed a technique for counting the number of fibers in an area of known size instead of measuring the diameter of individual fibers. These two investigators, and also Pohle (*11*), suggested comparing the image of a cross section of unknown mean diameter and variability with that of a cross section for which these two characteristics are known.

EXPERIMENTAL MATERIAL

Samples of wool from each of 10 Rambouillet yearling ewes from the breeding flocks of the Western Sheep Breeding Laboratory, Dubois,

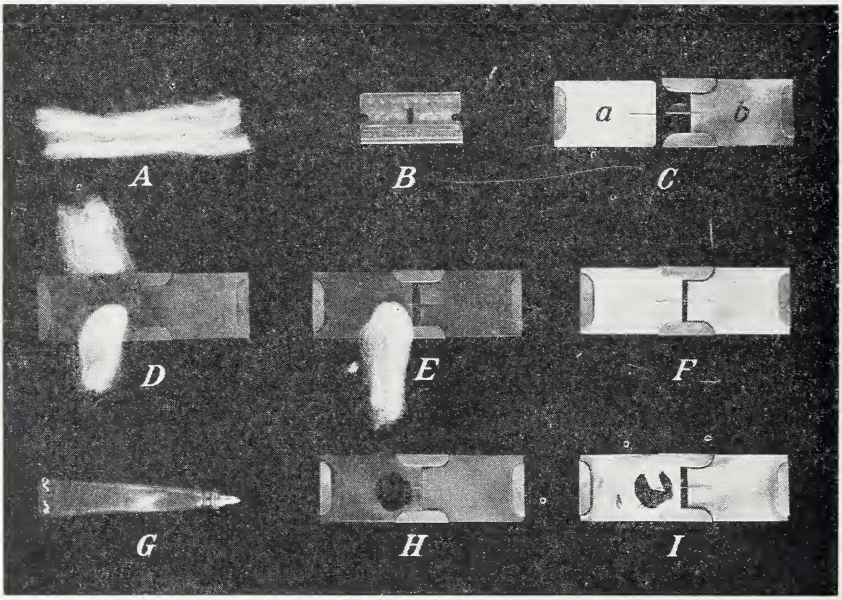

FIGURE 1.—Steps in the preparation of cross sections of wool fibers: *A*, Clean lock of wool; *B*, razor blade to be used in cutting the wool; *C*, device unassembled in which *a* is the fiber holder with slot and *b* the slide holder with metal plunger to hold fibers firm; *D*, slot filled; *E*, wool cut from one side; *F*, wool cut from both sides; *G*, black imbedding medium; *H*, device with imbedding medium smear; *I*, final cut over slot prior to inspection and projection.

Idaho, were taken during May 1939. Three samples were taken from each of the following 6 regions on the animals: Withers (at top of withers), back (middle of back), rump (on back anterior to the dock), shoulder (over point of scapula), side (at middle of side), and hip (over point of hip bone). Each sample was approximately 2 to 3 mm. in diameter and was clipped close to the skin with a pair of curved dissecting scissors. All samples were cleaned in carbon tetrachloride to remove extraneous material. Figure 1 shows the steps in the preparation of cross sections of wool fibers. All cuts were made under a low-power binocular microscope magnifying 12.5 times, and the cross sections were examined under a microscope magnifying 100 times before being

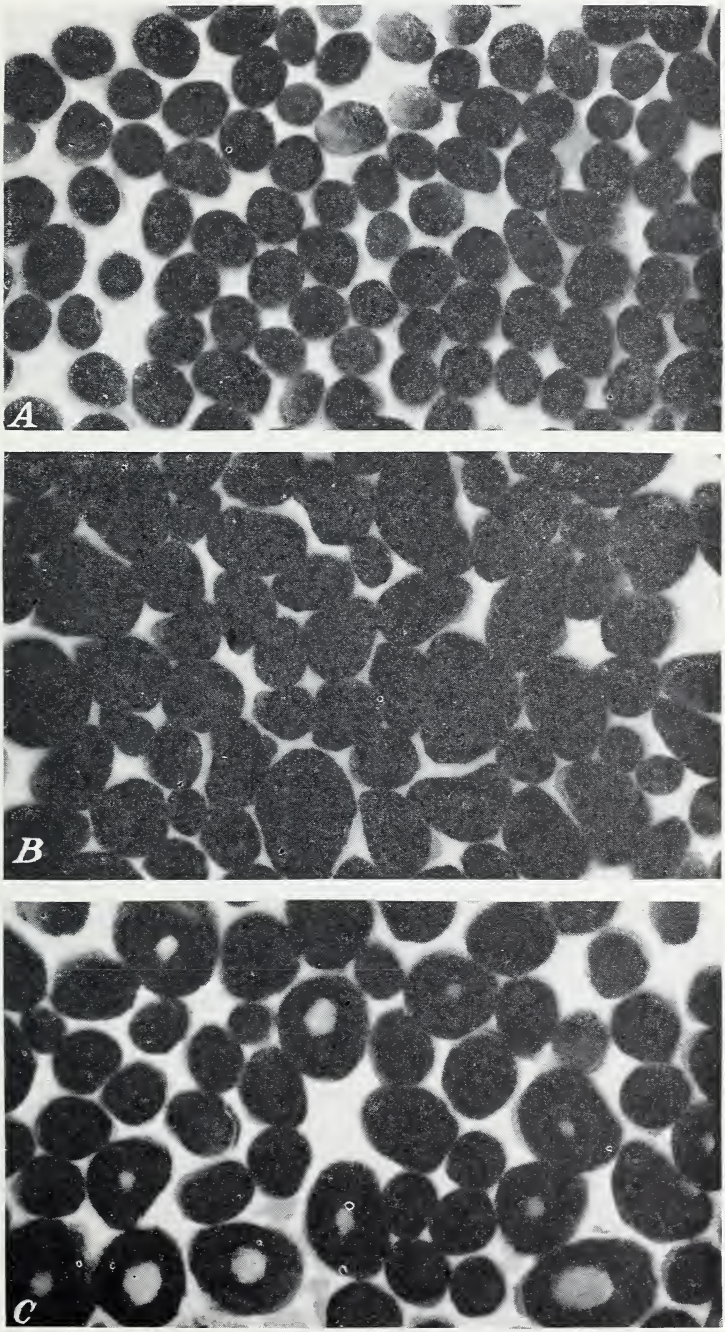

FIGURE 2.—Representative cross sections of wool fibers of *A*, uniform diameter; *B*, nonuniform diameter and poor ovality; and *C*, medullated fibers. Uniformity and ovality of fibers and freedom from medullation are sought in the fleeces of breeding sheep.

photographed or inspected under the microprojector as illustrated in figure 4.

In 4 groups of data obtained on the 180 wool samples, the following 4 methods were employed either in sampling or in measuring fineness and uniformity.

In group 1, photomicrographs of wool fibers prepared as shown in figure 1 and magnified 500 times (fig. 2) were made from the 3 locks of wool from each of the 6 body regions at 3 levels (15 mm. from the base, at the middle, and 15 mm. from the tip) on each lock. Fiber-

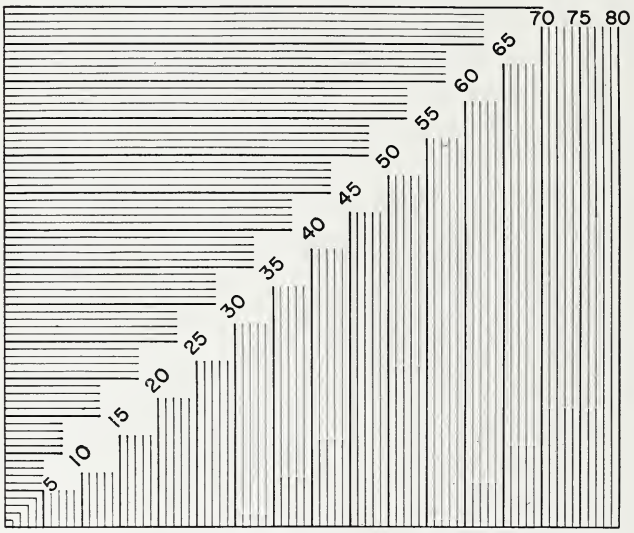

FIGURE 3.—Bidiameter scale for measuring individual fiber diameters.

diameter measurements were taken with a bidiameter scale (fig. 3) on 200 adjacent fibers from each of the 540 photomicrographs.

In group 2, locks of wool as nearly equal in size as possible from the 6 body regions of each ewe were blended with a pair of hand sampling cards. The fibers had been cut in several places before carding, because cross sections had been prepared from the base, middle, and tip of each lock. Photomicrographs of 2 cross sections were made from each of the 10 blended samples, 50 fibers being measured on each of the 20 photomicrographs.

In group 3, four photomicrographs from duplicate blended cross sections were prepared for each fleece. Mean diameter and variability were determined for each photomicrograph by counting the number of fibers in a 125-sq. cm. area, as described by Hardy and Wolf (*7*).

In group 4, mean diameter and variability were estimated independently by two operators from each of the 40 cross sections prepared for group 3 by the comparator method as illustrated in figure 4 and described by Pohle. (*11*).

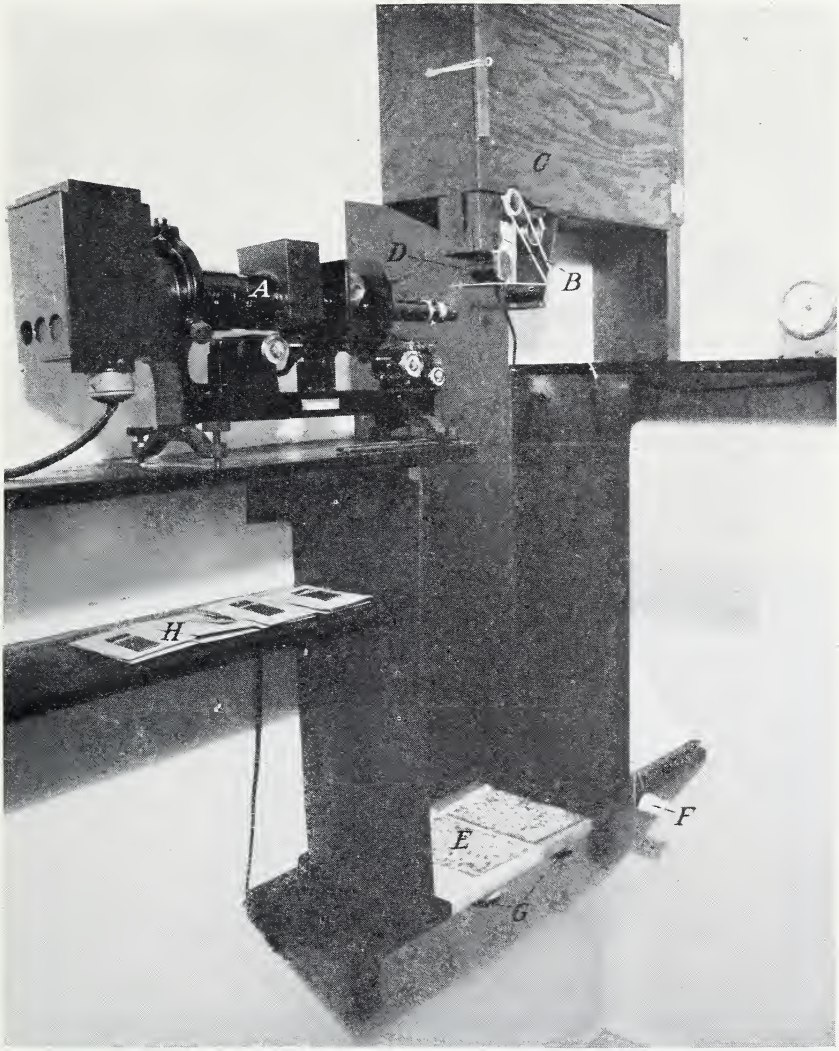

FIGURE 4.—Equipment and apparatus used in estimating fineness and uniformity by the rapid comparator method: *A*, Horizontal type of microprojector which magnifies, from a cross-section device, the wool sample whose diameter and uniformity are unknown; *B*, 35-mm. film-strip projector with known fiber diameter and uniformity standards for each micron from 16 to 42, which covers the range for domestic grades of wool; the standard lamp house on the 35-mm. projector was removed and the projector mounted in a specially constructed large (*C*) lamp house to give greater circulation of air for cooling, thus longer life to the bulb and elimination of all light reflections from the projector; *D*, film magazine constructed to care for film during projection; *E*, receiving screen—the image from the 35-mm. film is projected through an orange-colored filter onto a brown paper used as a receiving screen, whereas the sample image of unknown diameter is projected onto a dull white paper that makes both images of approximately the same light intensities; *F*, remote-control knob for 35-mm. projector for ease and rapidity in turning film for matching the proper standard with the unknown; the two projectors are mounted so that they show wool fibers at 500 × magnification, the known standard appearing on the right and the unknown on the left, adjacent to each other; *G*, switch for each projector; *H*, cross sections prepared for projecting and evaluating.

In view of the interest on the part of investigators in the use of hand sampling cards (fig. 5) for blending or carding wool, the following instructions are given:

(1) The operator should be sitting down; (2) grasp a card with the right hand, place on the left knee with the teeth up and the handle of the card to the right; (3) grasp the other card with the left hand, place on top of the first card, with the teeth up and the handle to the left—now the cards should be resting on the operator's left knee ready to receive the wool to be carded; (4) place wool on the card that is on top; (5) grasp the handles of the cards, invert the right-hand card, and place on top (teeth should now be turned downward); (6) draw the right-hand card across the wool, bringing it completely across the bottom card (which is in the left hand) so that it straightens the fibers. Do this several times (four to six strokes).

To clean the cards, (1) place the tops of the cards together and draw them back and forth—rolling the wool into a fluffy swatch; (2) place this swatch on the card and repeat operations as above until it has received a total of 30 strokes, thus insuring thorough blending, according to data in table 2. Practice is usually necessary for an operator to become proficient.

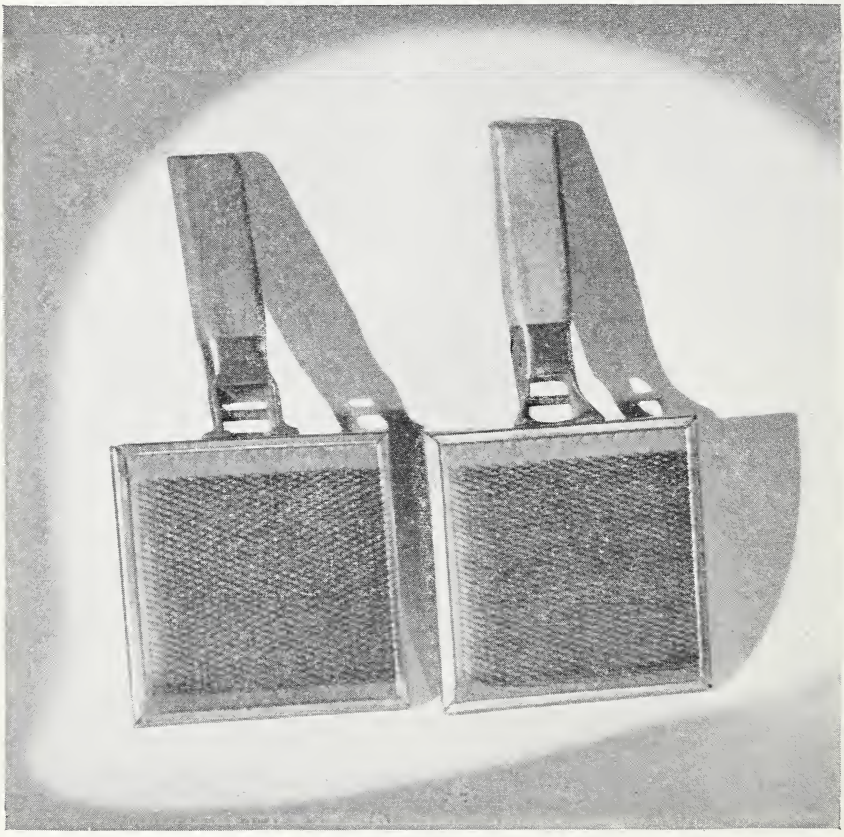

FIGURE 5.—Hand sampling cards.

RESULTS AND DISCUSSION

Sampling Methods

Sampling methods were compared for accuracy by measuring the variation associated with those sources of error most likely to be important in estimating mean diameter of individual fleeces and by examining theoretically how these errors are controlled or reduced by the different methods.

Table 1 shows the analysis of variance for the group 1 data, which were used to estimate the variation associated with possible sources of error in sampling. The size of the remainder indicated that the standard deviation within regions and levels is about 3.4 microns; hence, fibers differing by 15 microns or more may occasionally be found in the same lock of wool.

Table 1.—*Analysis of variance for group 1 data on 10 sheep*

Source of variation	Degrees of freedom	Mean square	F [1]	Interpretation	Component of variance
Sheep	9	17,188.2	[2] 18.40	$\sigma_e^2+600\,\sigma_{srl}^2+3,600\,\sigma_{sl}^2+1,800\,\sigma_{sr}^2+10,800\,\sigma_s^2$	$\sigma_s^2=1.5050$
Regions	5	2,694.2	[3] 4.20	$\sigma_e^2+600\,\sigma_{srl}^2+6,000\,\sigma_{rl}^2+1,800\,\sigma_{sr}^2+18,000\,\sigma_r^2$	$\sigma_r^2=0.1141$
Levels	2	23,755.0	[2] 25.60	$\sigma_e^2+600\,\sigma_{srl}^2+6,000\,\sigma_{rl}^2+3,600\,\sigma_{sl}^2+36,000\,\sigma_l^2$	$\sigma_l^2=0.6341$
Sheep × regions	45	428.6	[2] 2.03	$\sigma_e^2+600\,\sigma_{srl}^2+1,800\,\sigma_{sr}^2$	$\sigma_{sr}^2=0.1208$
Sheep × levels	18	716.9	[2] 3.39	$\sigma_e^2+600\,\sigma_{srl}^2+3,600\,\sigma_{sl}^2$	$\sigma_{sl}^2=0.1405$
Regions × levels	10	423.4	[3] 2.00	$\sigma_e^2+600\,\sigma_{srl}^2+6,000\,\sigma_{rl}^2$	$\sigma_{rl}^2=0.0354$
Sheep × regions × levels	90	211.2	[2] 18.08	$\sigma_e^2+600\,\sigma_{srl}^2$	$\sigma_{srl}^2=0.3325$
Remainder	107,990	11.7		σ_e^2	$\sigma_e^2=11.6835$

[1] The error term used in testing the significance of each main source was the sum of the 2-factor interactions involving that source minus the triple interaction. A conservative estimate of the degrees of freedom for the smaller mean square is the smaller of the degrees of freedom for the 2-factor interactions.
[2] Highly significant.
[3] Significant.

To estimate the variance associated with each source of error in order that it should be comparable with the basic variation within a lock $\left(\sigma_e^2\right)$, each mean square was equated to its theoretical interpretation (fifth column in table 1) beginning at the bottom and moving progressively up the table. By recombining these components (sixth column in the table) the standard error appropriate for a given sampling method and intensity of sampling can be calculated.

A lightly skirted Rambouillet ewe fleece is composed of 30 to 40 million individual fibers. Consequently, estimates of mean diameter must be made from samples that constitute a very small proportion of the total fleece. The process of excluding most of the fibers from the sample to be measured may be carried out in many ways, not all of which are equal in accuracy or in the amount of labor involved. The sampling procedure may vary from complete randomization of all sources of error to deliberate control of as many sources as possible.

The following formulas are appropriate for estimating the standard error of the mean diameter of individual fleeces when the sampling conditions for the different procedures are fulfilled.

In procedure A, in which n fibers are taken at random from each fleece,

$$s_A=\sqrt{\frac{\sigma_e^2+\sigma_{srl}^2+\sigma_{rl}^2+\sigma_{sr}^2+\sigma_{sl}^2+\sigma_r^2+\sigma_l^2}{n}}.$$

In procedure B, in which m fibers are taken at random from all levels at each of r definite regions for each fleece,

$$s_B=\sqrt{\frac{\sigma_e^2+\sigma_{srl}^2+\sigma_{rl}^2+\sigma_{sl}^2+\sigma_l^2}{mr}+\frac{\sigma_{sr}^2}{r}}.$$

In procedure C, in which k fibers are taken at random from each of r definite regions and l definite levels on each fleece,

$$s_C=\sqrt{\frac{\sigma_e^2}{krl}+\frac{\sigma_{srl}^2}{rl}+\frac{\sigma_{sr}^2}{r}+\frac{\sigma_{sl}^2}{l}}.$$

These formulas indicate how each source of error is controlled or reduced by the particular sampling procedure. The errors from all sources are reduced in proportion to $\sqrt{n}$ by procedure A. Differences between regions $\left(\sigma_r^2\right)$ do not influence the standard error by procedure B, since all fleeces are sampled at the same regions; however, σ_{sr}^2 is divided by r, the number of regions sampled, instead of by mr, the number of fibers measured per fleece. Procedure C would be most efficient when σ_r^2 and σ_l^2 are large as compared with σ_{sl}^2 and σ_{sr}^2, since differences between regions and levels do not influence the accuracy when fiber diameters of fleeces sampled at the same regions and levels are compared.

Figure 6 shows how the standard errors for the average diameter of individual fleeces are influenced by increasing the number of fibers measured with each procedure. Since each region and level sampled requires the preparation of one cross section, procedure A is most efficient in number of cross sections to be prepared and number of fibers measured. Procedure B is superior to procedure C in the same respect. The standard errors shown apply in practice only if the sampling conditions required for each procedure can be fulfilled. No data are available on the ability to randomize completely the fibers in a sample from the entire fleece as required for procedure A. The tendency for groups of fibers to adhere in locks indicates that complete randomization may be difficult to obtain. Hardy and Wolf (*8*) obtained smaller standard errors by mixing the fleece in a fleece opener and carding small samples from the mixed fleece than by other methods of sampling. This technique may fulfill the conditions required for procedure A if mixing and carding are thoroughly done.

Procedure *A* cannot be used by all workers because of lack of facilities and labor to handle whole fleeces in the laboratory. Physical limitations may require the taking of small samples from whole fleeces or from live sheep before shearing. Procedure *B* would be as accurate as procedure *A* if a sufficiently large number of regions could be sampled, but each region requires the sampling, cleaning, and preparation of an additional cross section and photomicrograph. An approximation to procedure *B* that requires only one cross section per fleece is that of mixing the fibers from the different regions before the cross section is made. This method will have a standard error slightly larger than

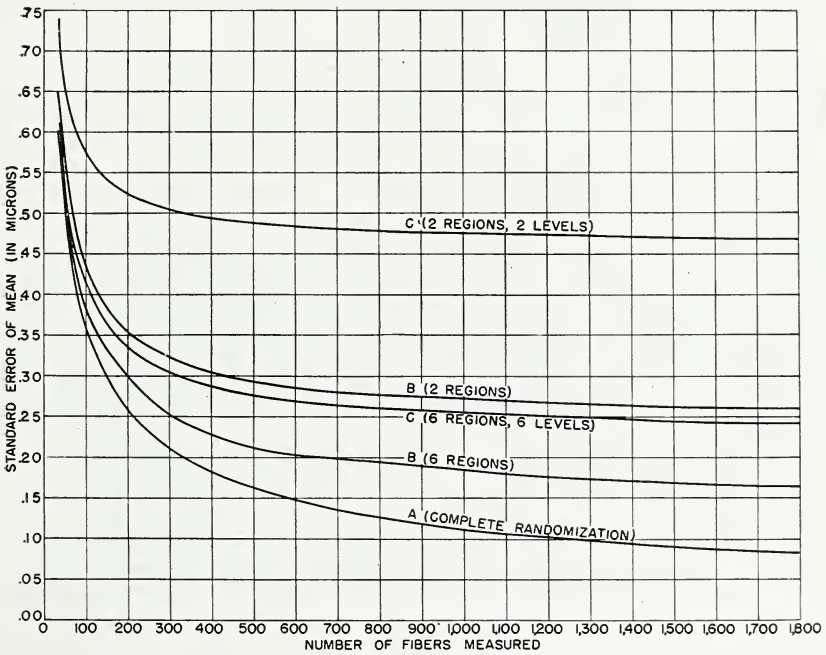

FIGURE 6.—Standard errors from the three sampling procedures for different numbers of fibers measured.

that given for procedure *B* because exactly the same number of fibers usually will not be measured from each region.

Malan and coworkers (*10*) mixed wool fibers by cutting them into small fragments and shaking them in ether. An alternative procedure is that used in the present study, namely, the hand carding of small locks from different regions of the fleece. This technique was tested to determine whether fibers from the different locks could be thoroughly mixed. First, 2 large locks of wool of the same grade were dyed different colors—one blue and the other yellow—and small equal-size samples of the 2 colors were carded with different degrees of thoroughness as indicated by the different numbers of strokes in table 2. Then cross sections for each blended sample were magnified 500 times, and the numbers of blue fibers in 96 horizontal rows of 5 fibers each were counted. This was repeated on 3 samples. The mixture was definitely nonrandom after 10 strokes. A random mixture can probably be achieved frequently after 20 strokes but with reasonable certainty only after 30 strokes.

TABLE 2.—*Effect of different degrees of carding on randomization of wool fibers*

Number of blue fibers	Theoretical frequency (50:50 ratio)	Observed frequency with the use of—		
		10 strokes	20 strokes	30 strokes
0	9	26	14	7
1	45	74	55	49
2	90	95	97	95
3	90	55	81	79
4	45	31	35	45
5	9	7	6	13
Percentage of blue fibers		40.8	46.0	50.1
x^2 for 50:50 ratio		24.2	4.7	0.0
x^2 for randomness of distribution		45.3	4.9	3.9

Additional information concerning the ability to mix fibers was obtained from the data for groups 1 and 2. First, the variance between cross sections for the same fleece in the group 2 data was slightly less than the remainder and hence was included in the remainder given in table 3. This indicated that the fibers from the 6 regions had been thoroughly mixed before the cross sections were made. Second, this remainder, containing differences between regions, levels, and the interaction terms, was a little larger than the remainder for the group 1 data, which represents the variance within locks. Third, none of the means of the 10 fleeces for the group 1 and group 2 data differ by twice the standard error of the mean difference. The indication, therefore, is that randomization can be obtained by thoroughly hand carding small locks of wool from different regions of the fleece.

TABLE 3.—*Mean squares for data groups 2, 3, and 4*

Source	Group 2		Group 3		Group 4	
	Degrees of freedom	Mean squares	Degrees of freedom	Mean squares	Degrees of freedom	Mean squares
Total	999	37.48	39	1.164	79	0.960
Sheep	9	180.86	9	4.493	9	6.867
Remainder [1]	990	12.447	30	.165	70	.200

[1] In each of the three groups of data the remainder contained nonsignificant sources of variation that are not shown.

The best kind and size of hand card for blending fibers appear to be influenced by the particular grade and staple of wool being sampled. Experience with a pair of specially prepared hand cards 3¼ by 3¾ inches in size (American gage No. 25, common pitch) has shown that coarse fibers mix more readily than fine fibers and that short fibers mix more readily than long fibers. Ease of mixing staples of wool can be increased materially by cutting the fibers into shorter fragments before carding, as cutting a 3-inch staple of fine wool into three lengths, which prevents the wool from rolling and knotting.

Precautions must be taken to obtain approximately the same number of fibers from each region in the blended sample. A device for this purpose was constructed as follows: A slot 3 mm. deep and 0.7 mm. wide was cut out of a piece of hard brass, which was 22 mm. long,

7 mm. wide, and 1.5 mm. thick. The brass was then mounted on a narrow wooden upright which, in turn, was mounted on a heavy wooden base. It was found that by firmly pressing a lock or bundle of uncleaned fibers into the slot and eliminating the excess fibers with a dissecting needle uniform bundles of fibers were easily obtained.

Measuring a large number of fibers or making repeated estimates of mean diameter from the same body region or level does not reduce the error resulting from inadequate sampling of the fleece. This was demonstrated by the formulas for the standard errors by sampling procedures *B* and *C*. When a restricted number of regions or levels is sampled, the term σ^2_{sr} or σ^2_{sl} may make up a large part of the sampling error. Furthermore, the degrees of freedom appropriate for testing the mean difference between fleeces is $r-1$ or $l-1$, whichever is smaller. The real advantage of blended samples lies in increasing the number of regions and levels sampled without increasing the number of cross sections that must be prepared.

Methods of Measuring Mean Diameter

The mean diameter of wool fibers for each of the 10 ewes is given in table 4 for the count and comparator methods (groups 3 and 4 respectively), as compared with the method of measuring individual fibers (groups 1 and 2). The agreement between the means obtained by measuring the fibers and those obtained by the short-cut methods is in general good enough for most practical purposes. When greater accuracy is desired, this can be achieved by making several estimates by the short-cut methods rather than by resorting to the longer procedure of measuring individual fibers. Neither the count nor comparator method shows evidence of being biased in the direction of overestimating or underestimating fineness. However, table 4 indicates that the finest and coarsest fleeces are likely to be estimated nearer the population mean by the two short-cut methods than they actually measure in most instances. This was further shown by the following estimates of σ^2_s (obtained as in table 1) from the four groups of data:

Group 1 (measuring individual fibers)	$\sigma^2_s = 1.505$
Group 2 (measuring individual fibers)	$\sigma^2_s = 1.684$
Group 3 (count method)	$\sigma^2_s = 1.082$
Group 4 (comparator method)	$\sigma^2_s = 0.833$

The estimates of σ^2_s for groups 2, 3, and 4 were obtained from the analysis of variance shown in table 3. A restriction of the range is commonly observed in most subjective estimates, such as that obtained with the comparator method, and is probably due to an operator's caution in making extreme estimates. Just why this tendency should exist with the count method is not clear, as the only procedure in which there is a possibility of subjective error is the estimation of the type of packing (loose, adjacent, or solid) in the cross-section photomicrograph.

TABLE 4.—*Mean diameter of wool fibers of the individual sheep for the 4 groups of data*

Sheep No.	Group 1 (measuring individual fibers)	Group 2 (measuring individual fibers)	Group 3 (count method)	Group 4 (comparator method)
	Microns	*Microns*	*Microns*	*Microns*
2120	16.89	16.00	16.95	17.38
149	17.92	18.11	18.28	18.38
99	18.47	18.01	18.98	18.50
2566	19.52	19.13	18.68	19.25
3910	19.65	20.22	19.22	19.75
2338	19.76	19.19	19.65	19.62
151	19.81	19.12	19.48	19.12
3897	20.28	19.52	19.45	19.62
2347	20.45	20.72	20.62	20.50
2397	21.05	19.85	20.42	20.12
Average	19.38	18.99	19.17	19.22

Estimates of fiber diameter by the count and comparator methods are averages of a number of fibers. The accuracy of single estimates can be expressed in terms of a theoretical number of fibers measured by comparing the remainder variances in table 3 for the short-cut methods (groups 3 and 4) with those obtained from group 2, as follows:

Group 3 (count method), $0.165=12.447/n$; $n=75$.
Group 4 (comparator method), $0.200=12.447/n$; $n=62$.

More complicated methods of estimating the theoretical accuracy of the short-cut methods gave figures consistent with those above.

With the count method, from 95 to 200 fine-wool fibers lie within the 125-sq. cm. area in which the fibers are counted. This number varies with the fineness of the wool and degree of packing. Single counts have an accuracy comparable with that of measuring 75 fibers, indicating that about one-half of the information is lost by counting instead of measuring the fibers in an area of corresponding size. The count method is probably more accurate for the fine wools used in this study than for coarser grades of wool because with the latter fewer fibers are contained in the area counted and the fibers are generally more oblate and irregular in cross section.

When making rapid comparator estimates of fineness and uniformity for fine-wool fleeces, from 300 to 500 fibers can be observed by the operator. Single rapid comparator estimates have a theoretical accuracy comparable with that of measuring 62 fibers. Since comparator estimates were made to the nearest micron, grouping errors are important in decreasing their accuracy.[3] By using smaller units of measure, the accuracy of single estimates could be increased, the limit in this respect being equivalent to that obtained by measuring 106 fibers. It is evident that averaging several independent estimates for each fleece would also give increased accuracy.

Both the count and rapid comparator methods appear to be unbiased and efficient methods of estimating average fiber diameter since single estimates by either method require much less time and calculation than measuring the number of fibers necessary to achieve corresponding accuracy. It is thought that the accuracy of the comparator method is less dependent on the grade of wool and type of packing than the count method, but the former requires more

[3] According to Sheppard's (*13*) correction, more than 40 percent of the remainder variance is due to grouping errors ($0.200-\frac{1}{12}=0.117$).

experience in operation than the latter. As with most methods in which estimates are substituted for objective measurements, accuracy can be attained only by frequent and repeated checking against measured samples.

Short-cut methods of estimating mean diameter will vary in accuracy in different laboratories, depending on the equipment and training of the personnel as well as on the grade of wool under study. The results reported herein are not intended to be estimates of the general accuracy of the two methods. An operator may ascertain the usual accuracy which he attains with either method and improve that accuracy by frequently checking his estimates against measured samples.

Methods of Estimating Uniformity of Fineness

Uniformity of fineness has been generally recognized as a desirable quality in the manufacture of yarns or fabrics. Hultz and Hill (*9, pp. 249–251*) emphasized the importance of three types of uniformity: (1) That over the entire fleece, (2) that of fibers growing side by side, and (3) that from base to tip. Von Bergen (*14*) presented standards for fineness grades of wool tops and gave maximum percentages of coarse fibers for each grade. Later, the American Society for Testing Materials (*1*) and the United States Department of Agriculture [4] adopted wool standards that contain minimum percentages of fine fibers and maximum percentages of coarse fibers for each fineness grade. Thus uniformity in diameter should be recognized in evaluating individual fleeces.

Table 5.—*Variances within fleeces for each of the 4 groups of data*

Sheep No.	Group 1 (measuring individual fibers)	Group 2 (measuring individual fibers)	Group 3 (count method)	Group 4 (comparator method)
	Microns	*Microns*	*Microns*	*Microns*
151	7.0	6.7	5.7	4.5
149	10.2	9.5	15.7	13.0
2347	10.6	10.1	9.8	7.2
2566	10.7	10.9	11.1	7.8
2120	10.8	9.5	9.8	12.8
99	12.6	12.5	9.0	10.2
2397	14.0	13.3	17.6	9.5
2338	15.3	13.4	14.3	13.8
3910	17.6	20.1	20.1	15.5
3897	18.1	18.6	23.7	17.8
Average	12.7	12.5	13.7	11.2

Table 5 shows the variances within fleeces for the 4 groups of data. The χ^2 test (*3*) for the homogeneity of variances applied to the data for groups 1 and 2 indicates that some fleeces are significantly more uniform than others. The short-cut methods also permit estimates of uniformity. With the count method the 2 smallest fibers are averaged and the 2 largest are averaged, and the difference is used in estimating the standard deviation of the entire group. With the rapid comparator method, the image of fibers of unknown fineness, in

[4] United States Agricultural Marketing Administration. methods for determining the grade of wool. wool standards. U. S. Bur. Agr. Econ. Serv. and Regulat. Announc. 135, Agr. Market. Admin. Amend. 2, 10 pp. 1942. [Processed.]

cross section magnified 500 times, is compared with standards of similar fineness that differ in uniformity. The average variance by both methods agreed very well with that obtained by the 2 measurement methods. Neither of the short-cut methods was accurate in estimating small differences in uniformity. However, extremely uniform and extremely variable fleeces were distinguished by both methods.

SUMMARY

Wool samples from 6 body regions on each of 10 Rambouillet yearling ewes were examined by the cross-section method to study the efficiency of sampling methods and of methods of measuring mean diameter and uniformity of individual fleeces. The work was carried on at the Western Sheep Breeding Laboratory, Dubois, Idaho.

The variations in fiber diameter associated with sheep, body regions, levels along the fiber, and the various interaction terms were found to be statistically significant.

Standard errors calculated from theoretical formulas indicated that samples of completely randomized fibers would be more efficient in both number of cross sections prepared and fibers measured per fleece than samples from controlled body regions or from controlled regions and levels along the fiber. Since the obtaining of samples of completely randomized wool fibers from individual fleeces appeared to require the opening and mixing of the whole fleece, a less efficient method of blending fibers from definite body regions, suitable for the usual wool laboratory, was investigated. The necessity of preparing a cross section of the fibers from each region sampled was avoided by mixing approximately equal numbers of fibers from the different regions prior to cross sectioning. Several trials indicated that the fibers could be mixed adequately by hand carding small locks of wool from different body regions.

Mean diameter and uniformity were estimated by measuring the enlarged diameters of individual fibers, by counting the number of fibers in an area of 125 sq. cm., and by comparing the image of a sample of unknown diameter with those of standards of known diameter. The accuracy of single estimates of fineness by the count and rapid comparator methods was equivalent to that of measuring approximately 75 and 62 fibers, respectively. Both are much faster to apply than measuring an equivalent number of fibers. Average fiber diameter estimated by both methods appeared to be unbiased, although some evidence was obtained that the deviations of the finest and the coarsest fleeces from the average were underestimated.

Both short-cut methods were sufficiently accurate to distinguish between uniform and variable fleeces; however, they were not very accurate in discerning small differences in uniformity.

LITERATURE CITED

(1) American Society for Testing Materials.
1942. A. S. T. M. STANDARDS ON TEXTILE MATERIALS. 408 pp., illus. Philadelphia.
(2) Bailey, B.
1940. DIAMETER RELATIONSHIPS OF WOOL FIBERS FROM FIVE BREEDS OF SHEEP RAISED IN SOUTH DAKOTA. Jour. Agr. Res. 60: 415–426.
(3) Bartlett, M. S.
1937. PROPERTIES OF SUFFICIENCY AND STATISTICAL TESTS. Roy. Soc. London Proc., Ser. A, 160: 268–282.
(4) Burns, R. H.
1931. FLEECE ANALYSIS IN SHEEP. Amer. Soc. Anim. Prod. Proc. 24: 246–258.
(5) Ensminger, M. E.
1942. FIBER DIAMETER STUDIES OF DIFFERENT BODY AREAS. Jour. Anim. Sci. 1: 355–356.
(6) Hardy, J. I.
1935. DETERMINATION OF FIBER FINENESS AND CROSS-SECTIONAL VARIABILITY, AN IMPROVED TECHNIQUE FOR OBTAINING PHOTOMICROGRAPHS BY PROJECTING CROSS-SECTIONS ON SENSITIZED PAPER. Jour. Textile Res. 5: 184–190, illus.
(7) ——— and Wolf, H. W.
1939. TWO RAPID METHODS FOR ESTIMATING FINENESS AND CROSS-SECTIONAL VARIABILITY OF WOOL. U. S. Dept. Agr. Cir. 543, 16 pp., illus.
(8) ——— and Wolf, H. W.
1943. SAMPLING FLEECES FOR DETERMINING AVERAGE WOOL FINENESS. U. S. Dept. Agr. Cir. 680, 8 pp., illus.
(9) Hultz F. S., and Hill, J. A.
1931. RANGE SHEEP AND WOOL. 374 pp., illus. New York.
(10) Malan, A. P., Carter, H. B., and Van Wyk, C. M.
1938. WOOL STUDIES. III. THE UNIFORMITY OF A SERIES OF FIBER THICKNESS MEASUREMENTS ON A SMALL SAMPLE OF MEDIUM MERINO WOOL. Onderstepoort Jour. Vet. Sci. and Anim. Indus. 10: 445–466.
(11) Pohle, E. M.
1940. THE APPLICATION OF A RAPID COMPARATOR METHOD FOR DETERMINING FINENESS AND VARIABILITY IN WOOL. Amer. Soc. Anim. Prod. Proc. 33: 161–168, illus.
(12) ——— and Schott, R. G.
1943. WOOL FINENESS IN EIGHT SAMPLING REGIONS ON YEARLING RAMBOUILLET EWES. Jour. Anim. Sci. 2: 197–208, illus.
(13) Sheppard, W. F.
1898. ON THE CALCULATION OF THE MOST PROBABLE VALUES OF FREQUENCY-CONSTANTS, FOR DATA ARRANGED ACCORDING TO EQUIDISTANT DIVISIONS OF A SCALE. London Math. Soc. Proc. 29: 353–380.
(14) Von Bergen, W.
1935. TESTING THE PHYSICAL AND CHEMICAL PROPERTIES OF WOOL BY MEANS OF THE MICROSCOPE. Amer. Soc. Testing Mater. Proc. 35: 705–726, illus.
(15) Wilson, J. F.
1929. A MACROSCOPICAL ANALYSIS OF THE FLEECES OF FOUR ROMNEY RAMS. Hilgardia 3: 583–594, illus.

U. S GOVERNMENT PRINTING OFFICE: 1946

LIBRARY
CURRENT SERIAL RECORD
MAR 31 1947
U. S. DEPARTMENT OF AGRICULTURE